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DETERMINATION OF THE SPACE-LATTICE OF A TRICLINIC MINERAL BY MEANS OF THE WEISSENBERG X-RAY GONIOMETER

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In the Weissenberg x-ray goniometer a simultaneous translation of the cylindrical film coupled with the rotation of the crystal permits a unique and rigorous determination of the space-lattice,[1] as Weissenberg[2] has stated. Weissenberg has pointed out that whereas the Debye-Scherrer powder photograph supplies one experimental parameter (the radius of the Debye-Scherrer circle), and the rotation layer-line photograph supplies two experimental parameters, μ, α, by the measurement of the two coordinates of the diffraction spot on the film, the Weissenberg x-ray goniometer supplies three experimental parameters, μ, α, σ. Now a series of parallel net-planes has only three degrees of freedom in a Bravais lattice, namely, the separation of the planes and the two degrees of freedom of the normal used up when its direction is fixed. Thus each net-plane is uniquely determined by the three parameters obtained by means of the Weissenberg goniometer. It should be stated that the modification of the rotation method usually called the oscillation method also permits a determination of the lattice of a triclinic crystal by measurements on x-ray photographs alone if the crystal can be rotated about three crystallographic zone-axes.[3] However, the Weissenberg goniometer yields a solution of this problem with one adjustment of the crystal (with any crystallographic zone parallel with the rotation axis) and in a direct and convenient manner, whereas the solution afforded by the rotation-oscillation method is roundabout and laborious and in some cases physically impracticable owing to the character of the crystals.

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[1] In this paper the term space-lattice is used in the sense of the system of points and is held not to imply the crystallographic axes by means of which the system of points is described since the same system of points can be described by an infinite number of sets of axes in the triclinic system. The present usage is in accord with the following:

Schoenflies, A., Krystallsysteme und Krystallstructur, S. 250, 1891.

Niggli, P., Lehrbuch der Mineralogie, I. Allgemeine Mineralogie, 2. Aufl., S. 19, 1924.

Wyckoff, R. W. G., The Analytical Expression of the Results of the Theory of Space Groups, Second edition, p. 25, 1930.

Hilton, H., Mathematical Crystallography, p. 115, 1903.

Mauguin, Ch., La Structure des Cristaux, p. 8, 1924.

Friedel, G., Leçons de Cristallographie, p. 16, 1926.

[2] *Zeit. f. Physik*, **23**, 229, 1924.

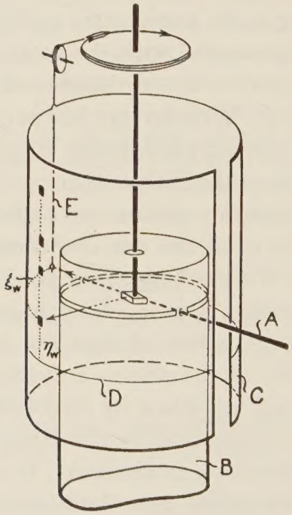

Fig. 1. Schematic representation of the Weissenberg x-ray goniometer. (After Böhm.) *Legend*: A, X-ray beam; B, Layer-line screen; C, Film-cylinder; D, Axis of ξ_w; E, Axis of η_w.

The first step in an analysis with the Weissenberg goniometer is to take an ordinary rotation photograph (film-cylinder stationary). On the rotation picture it is, however, only necessary to measure the separations of the layer-lines, these measurements determining the values of the parameter, μ, for the layer-lines. The angular distance from the equator to the layer-line being μ, one has the relation, $\tan \mu = s/r$, where s is the distance from the equator to the layer-line measured on the film and r is the crystal-to-film distance. The value of μ for each layer-line is then used to set the so-called layer-line screen of the Weissenberg goniometer. This screen is a metal cylinder of diameter slightly less than that of the cylindrical film; the screen is cut by a peripheral slit (the plane of the peripheral circular slit is at right angles to the axis of the cylinder) which permits the diffraction spots of only one layer-line to register on the film at each setting of the screen. The spots of this layer-line are spread out over the cylindrical film by the translation of the film carriage during the rotation of the crystal. After exposure and development, the film is laid upon a flat surface[4] and the rectangular coordinates of each diffraction spot are measured. For these measurements one coordinate axis, the η_w-axis, is a line that was parallel with the rotation axis during the exposure and passed through the center of the direct x-ray beam. In the case of a layer-line of a triclinic crystal the direction of the η_w-axis on the film is fixed by two reference spots made by the direct beam with exposures of two or three seconds; the lateral position of the η_w-axis is fixed by two diffraction spots of the same plane of the space-lattice, the two spots lying at equal distances on opposite sides of the η_w-axis. The ξ_w-axis is an arbitrary line at right angles to the η_w-axis. From the ξ_w- and η_w-coordinates[5] of each diffraction spot the point of the reciprocal lattice[6] corresponding to it is quickly and easily obtained by the graphical construction of Schneider.[7] From ξ_w and η_w are obtained α and σ by the equations of Weissenberg

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[3] Cf. Bernal, J. D., Equations (25) and (27) on page 144, and equation (3) on page 125, *Proc. Roy. Soc.* (London), **113A,** 1926.

$$\alpha = \xi_w \frac{360}{2\pi r_F},$$

$$\sigma = \eta_w \frac{360}{\eta_{360}},$$

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[4] The measurement of the film can be carried out very well by means of an illuminated sheet of opal flashed glass held in a wooden frame to which the film can be clamped. A glass strip with a hair-line extends across the film and slides along a scale at right angles to the hair-line. A vernier attached to the glass strip allows the position of the hair-line to be read on the scale.

[5] It should be noted that the symbol ξ of Weissenberg has an entirely different signification from the symbol ξ of Bernal. Therefore Schneider has very properly used ξ_w in place of Weissenberg's ξ for the rectangular coordinate of the diffraction spot on the Weissenberg film and has followed Bernal's use of ξ for the cylindrical coordinate of the point of the reciprocal lattice.

[6] For the definition and properties of the reciprocal lattice see Bernal, J. D., *Op. cit.*, pp. 118–125. (Bernal defines the reciprocal lattice somewhat more generally than Ewald did in his original description.)

[7] *Zeit. f. Krist.*, **69**, 41, 1928.

where r_F denotes the radius of the film and η_{360} the translation of the film carriage corresponding to a rotation of the crystal of 360°. Schneider's graphical construction is illustrated in Figs. 2 and 3.

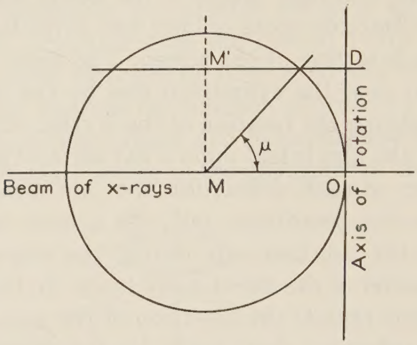

FIG. 2. Cross-section along the rotation-axis and through the center of the sphere of reflection. (Slightly modified after Schneider.)

Fig. 3 shows the piercing point of the rotation axis, D, also the circle, S_k, with radius r, cut out of the sphere of reflection by the plane of the diagram, and the center of the circle of reflection, M'.

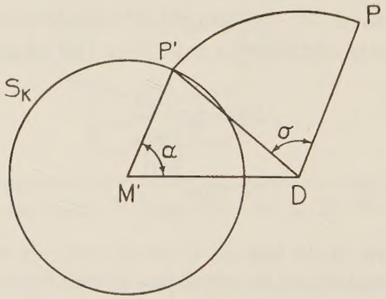

FIG. 3. Construction of the points of the reciprocal lattice. (After Schneider.)

Here $r = \cos \mu$. P is the point of the reciprocal lattice in the "initial position" (the "initial position" corresponds to the line chosen as the ξ_w-axis of coordinates), and P' the location of the same point at the moment of reflection.

The construction of the net-plane corresponding to the layer-line which is being analyzed is then accomplished as follows: The distance $M'D$ is laid off equal to unity (10 centimeters is convenient) and the circle of reflection is drawn with center M' and radius

$r = \cos \mu$ (10 $\cos \mu$ centimeters if $M'D$ be taken as 10 centimeters). Then the angle α is laid off from $M'D$ (counterclockwise for the side of the film that occupied the upper half of the film carriage, clockwise for the other side) and the point P' is found. Lastly the angle σ is laid off from DP' (clockwise or counterclockwise according to the direction of rotation of the crystal; with a uniform experimental procedure the sense of this angle is always the same for the same instrument). The construction is repeated for each diffraction spot on the Weissenberg photograph.

The analysis of the first layer-line, together with the spacing of the layer-lines obtained from the preliminary rotation photograph, suffices to build up the reciprocal lattice of any crystal, and the space-lattice is of course completely determined by and easily obtained from the reciprocal lattice since each plane of the space-lattice is perpendicular to the line from the origin through the point of the reciprocal lattice, and the spacing, $d_{(hkl)}$, of the plane in the space-lattice is connected with the distance of the point of the reciprocal lattice from the origin, $\rho_{(hkl)}$, by the equation

$$\rho_{(hkl)} \cdot d_{(hkl)} = k^2$$

where k^2 is an arbitrary constant usually set equal to the wavelength, λ, of the x-rays.

The data for a triclinic crystal obtainable with certainty and ease by means of the Weissenberg goniometer are thus: the coordinates of the points of the space-lattice; the indices of the plane of the space-lattice producing each diffraction spot; and the approximate intensity of the diffraction from each plane of the space-lattice estimated by means of the density of the spot on the film.

The choice of the crystallographic axes remains to be made and is not determined by the knowledge of the space-lattice since the same triclinic space-lattice can be described by means of an infinite number of different unit cells. However, the determination of the space-lattice by means of the Weissenberg goniometer makes it easy to choose the axes in such a way as to satisfy the law of Bravais as stated by Friedel,[8] according to which the pinacoids shall have the greatest spacings or reticular densities, and in the three zones between the pinacoids the unit prism and unit domes shall have the greatest spacings except the pinacoids themselves.

The relationship between the linear elements, that is, the axial ratios, a/b and c/b, and the axial angles, α, β, γ, and the unit cell dimensions, a_0, b_0, c_0, α, β, γ, is well known; that a similar close relationship exists between the polar elements of Victor Goldschmidt and the elements of the reciprocal lattice seems not to be well known but is very useful to remember. The angles of the reciprocal lattice, α^*, β^*, γ^* (notation of Bernal), are identically the polar angles, λ, μ, ν, of Victor Goldschmidt and the reciprocal lattice elements, a^*, b^*, c^* (notation of Bernal), differ from Goldschmidt's p_0, q_0, $r_0(=1)$ only by a constant, or in other words, $a^*/c^*=p_0/r_0$ and $b^*/c^*=q_0/r_0$. In the crystallographic system of Victor Goldschmidt each crystal face is represented by the point at which its normal intersects a horizontal plane, the plane of the gnomonic projection, and in the reciprocal lattice each plane of the space-lattice is represented by the point on its normal at a distance from the origin equal to $\lambda/d_{(hkl)}$. The reciprocal lattice can be considered to be made up of the points at the corners of Victor Goldschmidt's "Polarform" plus the points at the corners of the "Polarform" after translation successively parallel to each of its edges successive distances equal to the length and multiples of the length of the edge along which the translation took place, if the scales of the reciprocal lattice and "Polarform" be properly chosen. Owing to the common polar character of these two representations their elements are necessarily closely related.

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[8] *Op. cit.*, p. 20. Cf. also p. 17 and pp. 142–144.

THE SPACE-LATTICE AND OPTICAL ORIENTATION OF CHALCANTHITE ($CuSO_4 \cdot 5H_2O$): AN ILLUSTRATION OF THE USE OF THE WEISSENBERG *X*-RAY GONIOMETER IN THE TRICLINIC SYSTEM[1]

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The geometrical crystallography of chalcanthite, $CuSO_4 \cdot 5H_2O$, has been accurately determined by Tutton and by Barker. This substance is triclinic and thus the following discussion of x-ray measurements made by the present authors on an artificial crystal of chalcanthite will serve to illustrate the application of the Weissenberg x-ray goniometer in crystallographic measurements of triclinic substances, and also the relation of the measurements made with the x-ray goniometer to those made with the reflection goniometer.

TABLE 1.
LINEAR GEOMETRICAL ELEMENTS OF COPPER SULPHATE PENTAHYDRATE.

a	b	c	α	β	γ	
0.5715	1	0.5575	82°16′	107°26′	102°40′	Tutton
0.5721	1	0.5554	82°05′	107°08′	102°41′	Barker
0.563	1	0.546	—	—	—	Gossner & Brückl

The geometrical elements of Tutton[2] and of Barker[3] are given in Table 1 together with the axial ratio of Gossner and Brückl[4] obtained by x-ray measurements in combination with the axial angles of Barker. The measurements from which the axial ratio of Tutton was derived are recorded in his classical study of the crystals of copper sulphate pentahydrate. Barker's measurements on which his elements are based have not been published. The third line gives the axial ratio as calculated by Gossner and Brückl from their spacing measurements: $a_0 = 6.07$; $b_0 = 10.78$; $c_0 = 5.89$.

The orientation of Tutton and Barker is not entirely conventional, since the base slopes downward to the left, but will be retained in this paper in order that comparison of our results may be made with those of Tutton and of Barker. Tutton's choice of the principal or axial directions (as contrasted with his choice of positive and negative directions along the axes) is, however, most felicitous since the interplanar spacings of the three planes chosen as pinacoids by him are now found to be the greatest, second greatest, and third greatest, respectively, of any three non-tautozonal planes in the crystal; furthermore, in the three zones between the pinacoids the unit prism, (110), and unit domes, (101) and (011), have the greatest spacings except the pinacoids themselves.

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[1] Contribution to the Rinne Festschrift.

[2] Tutton, A. E. H., Crystallography and Practical Crystal Measurement, *London*, 1922, vol. **1**, pp. 282 ff.

[3] Groth, P., Chemische Krystallographie, *Leipzig*, 1908, Teil **2**, S. 419.

[4] Gossner, B. and Brückl, K., *Zeit. f. Krist.*, **69**, 422. 1929.

UNIT CELL DIMENSIONS OF COPPER SULPHATE PENTAHYDRATE

The crystallographic habit of copper sulphate pentahydrate permits an easy orientation of one zone, the axis of which has usually been taken as the *c*-axis. The crystal was mounted on the Weissenberg goniometer for rotation around this axis and, as will be shown in the sequel, a complete set of crystallographic elements was determined from purely röntgenographic measurements without changing the orientation of the crystal.

In order to obtain the greatest possible accuracy, soft *x*-radiation was used, in this case Cr-K-radiation, the wave length of which is $\lambda = 2.285$ Å.

(1) An ordinary rotation photograph around the *c*-axis was produced and from the separation of the layer-lines the spacing along this axis was found to be $c_0 = 5.95$ Å.

(2) One Weissenberg photograph of the first layer-line together with the rotation photograph would be sufficient to determine all the crystallographic elements as well as the absolute dimensions of the unit cell. A Weissenberg photograph of the equator was also taken, however, in order to obtain slightly more accurate values of three of the elements. From it the interplanar spacings normal to 010 and 100 were accurately determined from the higher order reflections of these pinacoids to be:

$$d_{100} = 5.724 \text{ Å}; \quad d_{010} = 10.385 \text{ Å}.$$

Also the crystallographic angle, ν (V. Goldschmidt's designation), which corresponds to the angle, γ^*, in the reciprocal lattice, was determined graphically from this film with the following result:

$$\nu = \gamma^* = 79° \, 15'.$$

(3) From a Weissenberg photograph of the first layer-line the other two crystallographic angles, λ and μ (V. Goldschmidt's designations), corresponding to the angles, α^* and β^*, respectively, in the reciprocal lattice were determined graphically with the use of the construction of Schneider[5] with the following results:

$$\lambda = \alpha^* = 94° \; 12'; \quad \mu = \beta^* = 74° \; 00'.$$

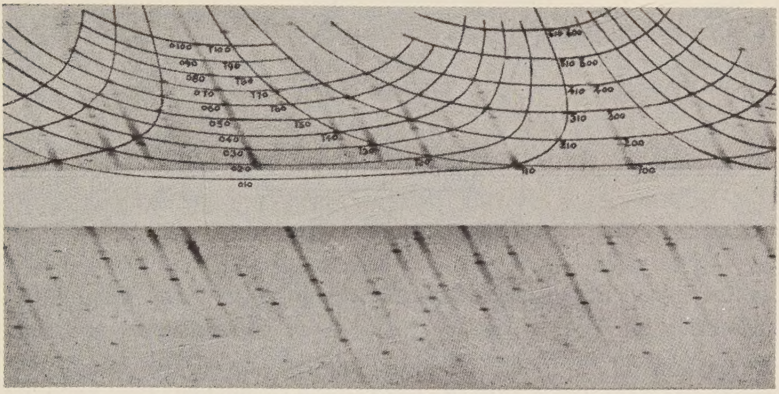

FIG. 1

Example of a Weissenberg photograph of a triclinic crystal: the equator line of chalcanthite (Mo-K-radiation). Only the set of curves for the α-spots has been drawn; a similar set of curves could be passed through the β-spots but this set would yield no new information.

(Note: This photograph taken with Mo-radiation was not used in the determination of the reciprocal lattice or crystallographic elements, for which purpose a photograph with Cr-radiation was taken; the photograph with the Mo-radiation of course contains more diffraction spots than that with Cr-radiation and is therefore more suitable as an illustration of a Weissenberg photograph of a triclinic crystal.)

It may be noted here that the graphical construction of Schneider leads directly to a determination of the elements of the reciprocal lattice, based on the *x*-ray measurements. The best numerical values of the reciprocal lattice were obtained, however, from the planar spacings, d_{100} and d_{010}, and the spacing along the rotation axis, c_0, by simple calculations, and are as follows:

$$a^* = 3.992; \quad b^* = 2.200; \quad c^* = 4.037.$$

Angles α^*, β^*, and γ^* as above. Since the unit parallelepiped of the reciprocal lattice, which is drawn in Fig. 2, is similar in shape and relative dimensions to the "Polarform" of V. Goldschmidt (α^*, β^*, γ^* correspond to λ, μ, ν, respectively, and a^*, b^*, c^* are proportional to p_0, q_0, $r_0(=1)$, see preceding paper by Tunell) it is obvious that the polar elements can be derived directly from the reciprocal lattice.

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[5] Schneider, W., *Zeit. f. Krist.*, **69**, 41, 1928.

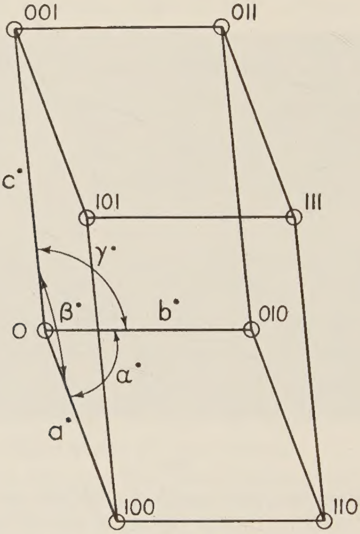

FIG. 2

Reciprocal lattice of chalcanthite ($CuSO_4 \cdot 5H_2O$). O is the origin of the reciprocal lattice.

(Note: The unit parallelepiped of the reciprocal lattice may be considered identical with the "Polarform" of Victor Goldschmidt if the scales of both be properly chosen.)

From the linear elements of $CuSO_4 \cdot 5H_2O$ of Tutton and from those of Barker the polar elements can also be calculated according to well-known crystallographic equations.[6] These calculations have been carried out and the following table gives a comparison of the three sets of polar elements of copper sulphate pentahydrate derived from Tutton's goniometrical measurements, from Barker's goniometrical measurements, and from purely röntgenographic measurements in the present investigation.

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[6] Goldschmidt, V., Index der Krystallformen der Mineralien, Bd. **I**, S. 78, 1886; Palache, C., *Am. Mineral.*, **5**, 188–189, 1920.

It should be noted that V. Goldschmidt uses the symbols, a_0, b_0, c_0, in these formulae in the sense of axial lengths referred to c_0 as unity, and *not* in the sense of the absolute lengths of the edges of the unit cell, as is customary among x-ray crystallographers; Palache gives the formulae in terms of the ordinary axial ratio, $a:b:c$, and axial angles, α, β, γ.

TABLE 2.
POLAR ELEMENTS OF COPPER SULPHATE PENTAHYDRATE.

	Tutton (Reflection goniometer)	Barker (Reflection goniometer)	Barth & Tunell (X-ray goniometer)
p_0	0.99074	0.98561	0.98885
q_0	0.54516	0.54403	0.54503
r_0	1	1	1
λ	94°15′	94°30′	94°12′
μ	73°47′	74°07′	74°00′
ν	79°05′	79°06′	79°15′

It may be seen that the accuracy of the Weissenberg method is quite satisfactory. It may also be stated that slightly better values could be obtained by this method if the crystal were rotated around the other two crystallographic axes as well as the c-axis. It is believed that greater accuracy than that obtained with the Weissenberg method can be secured with the reflection goniometer if the crystal faces are of a high degree of excellence, but not if the faces are dull, striated, or otherwise imperfect.

The crystals of copper sulphate pentahydrate used by Tutton in his classic investigation were of a very high degree of excellence and his angles are probably slightly more accurate than those obtained from the x-ray photographs. It is therefore probable that the most accurate values of the unit cell dimensions of $CuSO_4 \cdot 5H_2O$ are those obtained by combining Tutton's angles, α, β, γ, with our elements, a^*, b^*, c_0. The values for the unit cell thus obtained are:

$$a_0 = 6.110 \cdot 10^{-8} \text{ cm.}; \quad b_0 = 10.673 \cdot 10^{-8} \text{ cm.}; \quad c_0 = 5.95 \cdot 10^{-8} \text{ cm.};$$
$$\alpha = 82^\circ\ 16'; \quad \beta = 107^\circ\ 26'; \quad \gamma = 102^\circ\ 40'.$$

These values lead to the axial ratio:

$$a:b:c = 0.5725:1:0.5575,$$

which differs only slightly from that of Tutton given in Table 1.

OPTICAL ORIENTATION OF COPPER SULPHATE PENTAHYDRATE

Although it is such a common substance there is no general agreement as to the optical orientation of copper sulphate pentahydrate.

The optic axial angle was measured by Lavenir[7] to be $(-)2V = 56° 02'$, a value which is in close agreement with the one calculated[8] from the indices measured by Kohlrausch[9] and by Lavenir.[10]

The position of the optical indicatrix has been surveyed by Pape,[11] Lavenir,[12] Wulff,[13] Weber,[14] and Mélon,[15] with conflicting results.

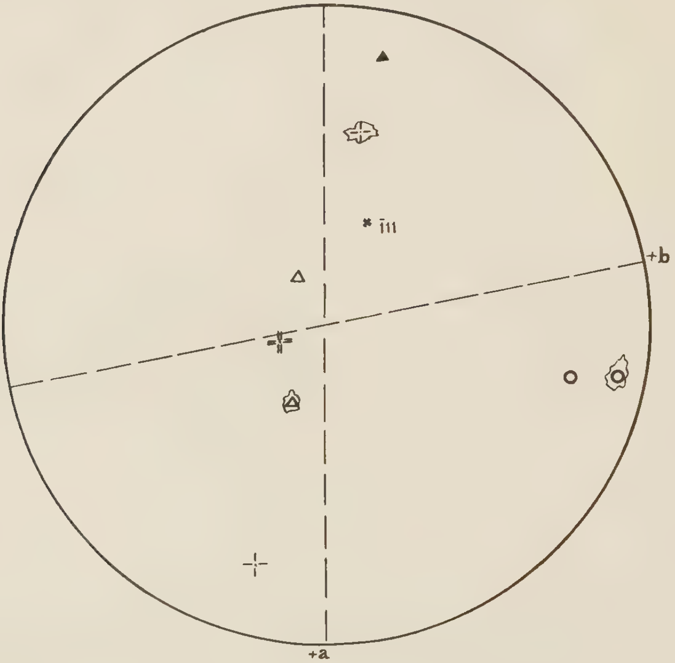

FIG. 3

Stereographic projection showing the supposed optical orientation of copper sulphate pentahydrate according to Pape, Weber, and Mélon.

	α	β	γ
Pape	○	┼	△
Weber	◎	⊕	◬
Mélon	○	╪	▲

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[7] Lavenir, A., *Bull. Soc. Française de Min.*, **14**, 100, 1891.

[8] Cf. Tunell, G. and Morey, G. W., *Am. Mineral.*, **17**, 406, 1932. (The value of 2V calculated by Lavenir is slightly inaccurate.)

[9] *Wiedemann's Ann. d. Physik und Chemie*, **4**, 30, 1878.

[10] *Op. cit.*

[11] Pape, C., *Pogg. Ann. d. Physik und Chemie*, Ergänzungsband **6**, 35, 1874.

The data given by Pape, Weber, and Mélon are reproduced in the stereographic projection of Fig. 3. The data of Lavenir have not been included, for the presentation of his observations is such that a unique interpretation of his data is impossible. It is not clear

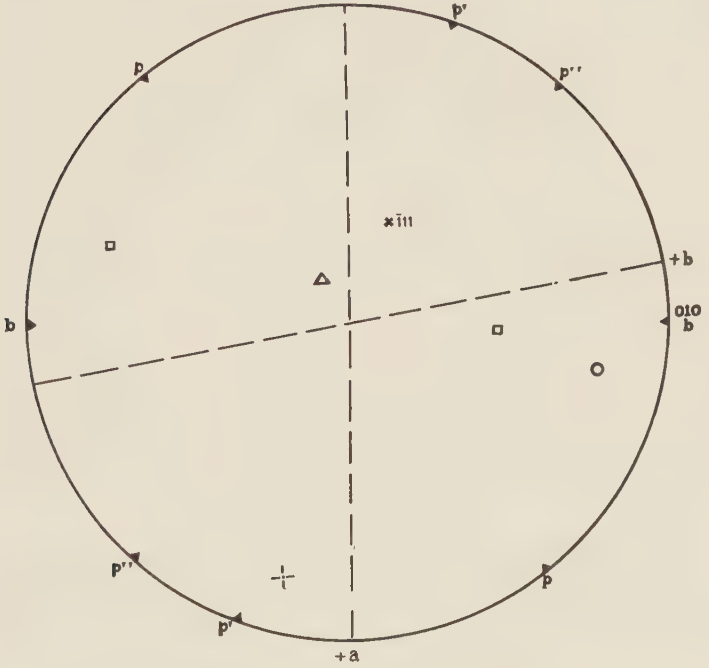

FIG. 4

Stereographic projection of the optical orientation of copper sulphate pentahydrate as determined by the present authors.

○ $=\alpha$, -¦- $=\beta$, △ $=\gamma$, □ = optic axis.

$2V_\alpha=56°$, $c:\gamma=18°$ in a plane forming 33° with 010, and $c:\alpha=76°$ in a plane forming 79° with 010. (Since there are two planes forming the same angle with (010) the projection serves to fix uniquely the directions of the axes of the optical ellipsoid.)

The orientation and the letters assigned to the faces are the same as those of Tutton.

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[12] *Op. cit.*

[13] Wulff, G., in Groth's "Chemische Krystallographie," *Leipzig*, 1908, Teil **2**, S. 420.

[14] Weber, L., *Mitt. Naturf. Gesellsch. i. Freiburg* (Schweiz) **4**, 103, 1921.

[15] Mélon, J., *Bull. Soc. Française de Min.*, **47**, 141, 1924.

whether Wulff's results are based on original observations or are recalculations of Pape's findings, with which they coincide.

The wide discrepancies shown in the stereographic projection of the data in the literature make a reinvestigation of the optical orientation of this substance imperative. The use of a Fedorov stage offers a simple and rapid method of determining the optical orientation of any triclinic crystal. Higher accuracy can be obtained by other methods but the accuracy of the measurements with the Fedorov stage is amply sufficient for most purposes.

Small, well faceted crystals of copper sulphate pentahydrate obtained by evaporation of a saturated solution were imbedded in canada balsam on microscope slides for optical study. The faces of the crystals were easily identified with the aid of the Fedorov stage. The average of several measurements of interfacial angles and extinction angles established the orientation represented in the second stereographic projection (Fig. 4).

A comparison of Figs. 3 and 4 shows that the measurements of the present authors are in good agreement with those of Pape; they also are in agreement with one of the four possible interpretations of Lavenir's data.

SUMMARY

The crystallographic elements of the triclinic substance, chalcanthite ($CuSO_4 \cdot 5H_2O$) have been determined by purely röntgenographic measurements with a Weissenberg goniometer (see Table 2).

The most accurate dimensions of the unit cell with the largest possible spacings in the directions normal to the three pinacoids are:

$$a_0 = 6.110 \text{ Å}; \quad b_0 = 10.673 \text{ Å}; \quad c_0 = 5.95 \text{ Å};$$
$$\alpha = 82° \, 16'; \quad \beta = 107° \, 26'; \quad \gamma = 102° \, 40'.$$

This unit cell corresponds to the choice of crystallographic axes made by Tutton and Barker, whose orientation therefore has been adopted.

The optical orientation of chalcanthite has been redetermined with a Fedorov stage and the results are represented in a stereographic projection (Fig. 4). They are in close agreement with the results of Pape.

CORVUSITE AND RILANDITE, NEW MINERALS FROM THE UTAH-COLORADO CARNOTITE REGION

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Introduction

In the carnotite-bearing deposits of Colorado and Utah the sandstone and accompanying clays are impregnated with many dark brown and black mineral masses, which show no crystal form to the unaided eye and few other definite characteristics. The most common of the dark colored minerals are listed below.

Roscoelite	vanadium mica
Rauvite	$CaO \cdot 2UO_3 \cdot 6V_2O_5 \cdot 20H_2O$
Vanoxite	$2V_2O_4 \cdot V_2O_5(8\pm)H_2O$
Corvusite	$V_2O_4 \cdot 6V_2O_5 \cdot XH_2O$
Rilandite	hydrous chromium aluminum silicate
Lignite	
Tar (?)	
Asphaltite	
Psilomelane	
Iron-copper-cobalt oxide.	

Two of the names, corvusite and rilandite, are new and are proposed in this paper. The authors hesitated to give names to such compounds as those to which they are applied because no entirely satisfactory formula can be offered for either, but since the substance called corvusite is common in the carnotite region a verbal handle seems necessary. Rilandite, although at present known from only one locality, was obtained in rather large quantity and its association is such that it seems likely that it will be obtained from other places in the carnotite region. If at some future date further study shows these names unnecessary they can easily be relegated to oblivion.

General Relationships

Roscoelite or a similar dark mineral is provisionally identifiable by the microscope from many places in this region. Roscoelite is well known, rauvite and vanoxite[1] and the asphaltite[2] have been described previously, and the other dark minerals are described in this article.

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[1] Hess, Frank L., New and known minerals from the Utah-Colorado carnotite region: *U. S. Geol. Surv. Bull.* **750,** pp. 63–78, 1924.

[2] Hess, Frank L., Uranium-bearing asphaltite sediments of Utah: *Eng. and Min. Jour. Press*, vol. **114,** No. 7, pp. 272–276, 1922.

In the specimens from which vanoxite was described, spaces between part of the sand grains were filled solidly with a black, or deep brown, mineral which exhibited shrinkage cracks that were inconsistent with a crystalline mineral. At that time it was not shown that this material was another mineral. When some of these specimens were viewed at certain angles the material had a purplish or bluish luster.

Some years ago one of us (F.L.H.) visited the Jack Claim, at that time owned by R. G. Hart and A. L. Tomlinson, on the east side of La Sal Mountains, Grand County, Utah, and about 10 miles west of Gateway, Colo., in which Mr. Hart had found peculiarly beautiful segregations of a mineral with a bluish luster much more pronounced than that of the previous material, and in masses evidently nearly pure. The best specimen, about 2½ inches square by 2 inches thick, was kindly presented to Mr. Hess and is now in the United States National Museum (No. 96806).

The material was found in sandstone of Morrison age (formerly called McElmo by the United States Geological Survey) beside a petrified log which was considerably decayed before petrifaction.

Carnotite and related minerals of the "carnotite region" of southwestern Colorado and southeastern Utah are found only with organic material, and in order to show the relations of the black minerals some discussion of the occurrence of both organic and dark vanadium minerals is necessary.

The vegetal remains take three ordinary forms: (1) macerated leaves and stems; (2) bundles or rolls of plants, like the twisted rolls of sea-weeds found on some present day beaches; and (3) wood ranging from twigs to logs 100 feet long and 6 feet or more thick at the butt. Besides these there are saurian bones and occasional bits of lignite which, however, have had little influence on the uranium and vanadium minerals. The first two forms of vegetal material are carbonized. The wood is petrified, and only where it was considerably decayed before petrifaction has there been any considerable deposition of uranium and vanadium minerals.

Black or dark roscoelite (or a closely related mineral) forms in halos and in thin zonal bands around the vegetal matter, including the wood, and is the commonest of the black minerals. In places it forms layers in the outer zonal bands so dense that the sandstone breaks away from them as if from distinct bedding planes and leaves rounded surfaces which are locally known as "rolls." The sandstones are cross-bedded and "rolls" cut through the cross-bedding planes at all angles. (Fig. 1.) In other words the halos or "rolls" are reversed concretions—they have moved outward from a center instead of toward it.

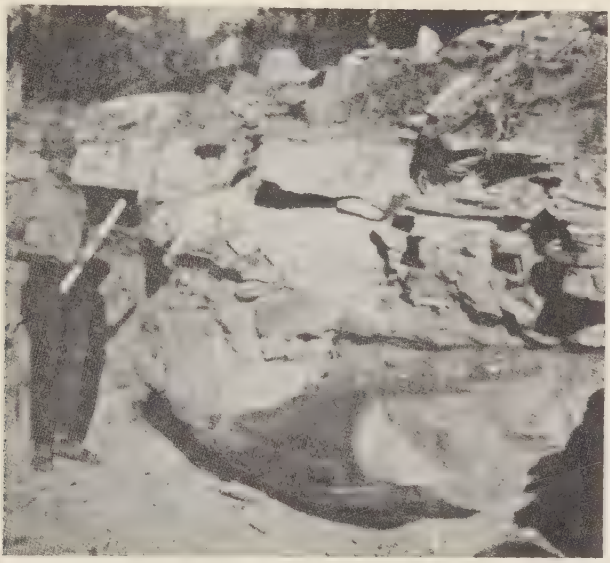

FIG. 1. A "roll" in sandstone formed by black roscoelite, in Morrison sandstone, Maverick Camp, 10 miles southeast of Gateway, Colo.

Roscoelite does not always form definite bands but it is sometimes found diffused through the sandstone in such a way as to give it a gray color, and even when spreading from a piece of fossilized wood it may diffuse gradually and have no definite boundary. (See Fig. 2.) In the densest bands and in some other places it is so black that it is difficult to distinguish from other black minerals except by means of the microscope.

Another black vanadium mineral forms massive aggregates which usually lie near the site of the minerals originally formed in the sediments, but its relationships are not always clear as it may travel a considerable distance from the nucleus. Except for roscoelite, it is found in greater quantity than any other of the dark minerals of the carnotite region. A black tarry substance exudes from some of these samples. The material studied from the Jack Claim and described farther on is believed to be of this type, but it contained no organic matter.

In places patches of sandstone are irregularly blotched and spotted by black minerals and sometimes impregnated with carnotite and allied minerals. Thin sections made from the black spots show vanoxite which is recognized by its crystal habit. Other black or nearly black minerals are also found which are, at present, assumed to be uranium minerals, but these have not been found in sufficiently pure segregations to be profitably studied.

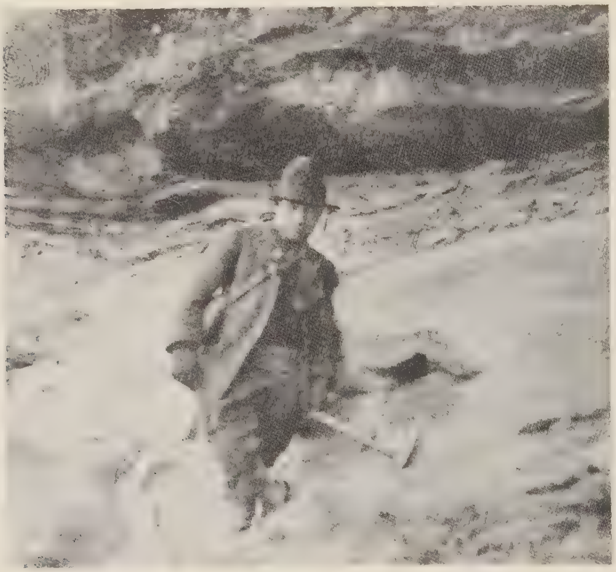

FIG. 2. Black roscoelite halo around a piece of fossil wood (now removed) in Morrison sandstone. East side of Carrizo Mountains, New Mexico.

Small pieces of lignite are enclosed in the sandstone and Kithil[3] has described one which contained uranium. Samples of the type lignite have been reexamined and it was found that the lignite itself is not radioactive. The specimens were in contact with the sensitive side of a photographic plate for four days and where free from visible carnotite did not affect the plate.

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[3] Kithil, Karl L., On the occurrence of a probable new mineral: *Science*, vol. **38,** pp. 624–25, 1913.

Rilandite, a peculiar black chromium compound, described in this article, is also found in the Morrison sandstone. Manganese dioxide discolors the sandstone in many places and in Sinbad Valley black spots which are composed of a mixture of iron, cobalt and copper oxides are found; at Temple Rock, shiny asphaltite carrying uranium, vanadium and other elements occurs. These last two occurrences are not in the Morrison formation, but are in lower rocks.

Corvusite

The name corvusite is derived from the latin word for raven (corvus), since this mineral has a purplish bluish-black color similar to that of a raven.

It is strange that although the mineral here described as corvusite is one of the commonest of the black minerals in the carnotite region, yet specimens suitable for analysis are very rare. The best material (Museum No. 96806) was that already referred to as collected from the Jack Claim located about 10 miles west of Gateway, Colo. Samples which are dark brown, instead of black, were collected from the Ponto No. 3 claim of the former W. L. Cummings Chemical Co., on the north wall of Gypsum Valley, San Miguel Co., Colo., at least 40 miles south and slightly east of the Jack Claim.

The best specimen has a purplish blue-black color and is massive, but due to the slickensides, shown on the material studied, it somewhat suggests a fibrous material. In its luster and slickensiding it is reminiscent of rauvite. There are numerous shrinkage cracks in the samples, some filled with gypsum and fervanite, and others open. The hardness is between 2.5 and 3, the fracture is conchoidal, and the specific gravity, determined by heavy solutions, is 2.82. The difference in color between the blue-black and brown specimens is explained by the higher iron content of the brown material (about 10 per cent Fe_2O_3). The streak of the two varieties is the same as the color of the specimens. The chemical compositions of the two types are so nearly alike that there is little doubt but that they are practically the same material.

Both types are soluble in mineral acids, but before complete decomposition is effected the color of the purplish blue material changes to a distinct brown, and is then more slowly soluble. At room temperatures, probably between 20° and 30°C, distilled water dissolved 8.10 per cent vanadic oxide, V_2O_5. Tests were made for the lower oxide of vanadium, V_2O_4, but none was found to be present.

The mineral being practically opaque under the microscope, the material analyzed was obtained by hand picking the coarsely crushed powder, selecting only the pieces which had the purplish blue or brown color, and, to the eye, were free from impurities.

Analysis of the Purplish Blue-black Corvusite

E. P. Henderson, analyst

Oxide	Per cent	Recalculated	Molecular values
Insol.	1.08		
Sol. SiO_2	0.30		
Na_2O	1.44	1.46	.0235
K_2O	1.06	1.08	.0115
CaO	1.98	2.01	.0359
MgO	0.27	0.27	.0068
Fe_2O_3	5.82	5.93	.0371
V_2O_4	9.67	9.82	.0614
UO_3	1.71	1.74	.0064
V_2O_5	64.89	65.86	.3617
H_2O	11.68	11.87	.6585
	99.90	100.04	

The molecular ratios have been combined in many different ways yet no entirely satisfactory formula was obtained which included all the various elements found, therefore only the tentative formula, $V_2O_4 \cdot 6V_2O_5 \cdot X\ H_2O$, is proposed.

THE DULL BROWN CORVUSITE. The physical properties of this variety (Museum No. 96807) agree in general with those of the purplish material, but the streak is yellowish brown. Suggestions of a purplish color are also visible in the brown material.

Several years ago W. T. Schaller analyzed some dark colored vanadium compounds (collected by F.L.H.) from the same claim. His analyses have not been previously published and by his courtesy they are given in a following table for comparison.

The most striking similarity between these analyses is in the constant ratios between the two vanadium oxides V_2O_4 and V_2O_5. The average ratio of these four analyses is almost exactly 1 V_2O_4 to

ANALYSIS OF THE DULL BROWN CORVUSITE

E. P. Henderson, analyst

Chem. symbol	Per cent	Recalculated for insoluble	Ratios
Insol.	21.52		
Sol. SiO_2	3.30	4.21	.0694
MoO_3	0.22	0.28	
CaO	0.32	0.40	.0071
MgO	1.63	2.07	.0513
Na_2O	0.98	1.24	.0200
K_2O	1.69	2.15	.0228
V_2O_4	5.99	7.62	.0458
V_2O_5	39.78	50.68	.2785
Fe_2O_3	9.58	12.20	.0764
UO_3	2.31	2.94	.0102
H_2O	12.32	15.83	.8785
	99.64	99.58	

ANALYSES OF CORVUSITE FROM THE CARNOTITE REGION

	E. P. Henderson, analyst		W. T. Schaller, analyst	
	Purple	Brown	Dark purple-black	Dull brownish black
	1	2	3	4
Insol.	1.08	21.52	0.16	0.17
Sol. SiO_2	0.30	3.30	0.63	2.19
CaO	1.98	0.32	1.85	1.70
MgO	0.27	1.63	Not det.	Not det.
V_2O_4	9.67	5.99	10.26	10.13
K_2O	1.06	1.69	Not det.	Not det.
Na_2O	1.44	0.98	Not det.	Not det.
V_2O_5	64.89	39.78	69.00	65.24
Fe_2O_3	5.82	9.58	1.69	0.99
UO_3	1.71	2.31	1.16	3.12
H_2O	11.68	12.32	13.52	14.09
MoO_3	Not det.	.22	.16	.18
	99.90	99.64	98.43	97.81

Comparison of Ratios between V_2O_4 and V_2O_5

V_2O_4	.0582	.0360	.0618	.0610
V_2O_5	.3566	.2186	.3792	.3586
V_2O_4	1	1	1	1
V_2O_5	6.01	6.07	6.02	5.87

6(5.99)V_2O_5. The samples were collected from different areas in the field and the material was independently prepared and analyzed by two analysts, and it is difficult to see how this constant ratio would result unless there is a compound formed between the two vanadium oxides. The name corvusite is proposed for the compound $V_2O_4 \cdot 6V_2O_5 \cdot XH_2O$. All of the analyses have a rather similar water content yet it is impossible to determine how much of the water belongs with corvusite and how much is combined with the extraneous matter present.

Vanoxite has a black color and even if the general appearance of corvusite were mistaken for vanoxite the two compounds are so different chemically that it is easy to distinguish between the two.

Vanoxite $2V_2O_4 \cdot V_2O_5 \cdot 8H_2O$
Corvusite $V_2O_4 \cdot 6V_2O_5 \cdot XH_2O$

Rilandite, a New Chromium Mineral

The black material described here is from a claim located for carnotite by Mr. J. L. Riland, the veteran newspaper publisher of Meeker, Colorado, and was sent some years ago to one of us (F.L.H.) after a visit to the claim. It seemed incredible that a black material of the weathered zone could contain such high percentages of chromium. Recently E. P. Henderson visited the claims and Mr. Riland reported finding the mineral in a number of petrified logs. He also presented the U. S. National Museum with additional specimens (No. 96808). Mr. Riland's carnotite claims are a little more than 13 miles east and somewhat north of Meeker and are in sandstone which is apparently in the lower part of the Morrison formation, and therefore of the same age as the carnotite deposits in the better known area in southwestern Colorado and southeastern Utah. The sandstone was at first erroneously identified as Dakota (Cretaceous) by Gale,[4] but in a later paper[5] they were referred to the Jurassic.

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[4] Gale, H. S., Carnotite in Rio Blanco County, Colo.: *U. S. Geol. Surv. Bull.* **315**, pp. 110–117, 1907.

[5] Gale, H. S., Carnotite and associated minerals in western Routt County, Colo.: *U. S. Geol. Surv. Bull.* **340**, pp. 258–259, 1908.

The material under consideration was found with a fossil log, but in no great quantity. It is not known to have been found elsewhere, although other chromium minerals have been found in the sandstones of the carnotite region. Gale[6] says that at the carnotite deposits in Routt County some of the sandstone is stained by a chromium mineral and Ransome collected, near Sinbad Valley, sandstones probably of La Plata age that were stained green by a chromium mineral.[7] At Placerville a chromium mineral, probably mariposite,[8] is found both with a vein in a Dolores (?) limestone, and with vanadium deposits in the overlying La Plata sandstone. On the southwest side of the La Sal Mountains, Utah, small quantities of a chromium bearing chloritic mineral were found (by F.L.H.) filling tiny cracks in Morrison sandstones.

Description of the Material. Mr. Riland's material in some ways resembles dull pitch. It is massive, compact, with a dark brownish black color and breaks with a flat conchoidal fracture into granules some of which show a rather brilliant surface. When a quantity is spread out for study it is noticed that in general it has an angular platy habit.

It is very brittle, the hardness is between 2 and 3, and the streak is grayish brown.

In a few places there are films of a greenish alteration product, but other than this slight film there is nothing about the specimen suggesting a compound that is nearly half chromic oxide.

The chromium bearing material is confined to the outer surfaces of the petrified wood although it fills shallow recesses. The addition of the compound to the wood took place after the wood had been petrified as there is no evidence of any dark pigment in the inner portions of the specimen, and no woody structure is noticeable in the chromium material, but when pieces are broken off from the outside, the imprint of the wood is rather conspicuous.

The fossil wood was referred to Mr. C. B. Read of the United States Geological Survey who reports:

"This specimen shows the typical early cupressinoid type of wood structure. It compares in some respects with *Cupressinoxylon*

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[6] *Op. cit.*, p. 261.

[7] Hillebrand, W. F., and Ransome, F. L., On carnotite and associated vanadiferous minerals in western Colorado: *U. S. Geol. Surv. Bull.* **262**, p. 14, 1905.

[8] Hess, Frank L., Notes on the vanadium deposits near Placerville, Colorado: *U. S. Geol. Surv. Bull.* **530**, pp. 148 and 151, et. al., 1917.

macrocarpoides, Penh. from the Cretaceous of Canada, but the indifferent preservation will not allow a critical study."

The sample was prepared for chemical analysis by selecting a number of pieces and brushing each piece with a stiff brush to remove the adhering brownish film of dust. It was hand-picked a second time and only those pieces which had a brilliant black surface were selected. The only assurance that the selection was uniform was the appearance under the binocular because the compound is almost opaque under the microscope.

ANALYSIS OF RILANDITE

E. P. Henderson, analyst

		Ratios		
SiO_2	9.98	.1646	.1646	1
Cr_2O_3	47.59	.3093	.4911	3
Al_2O_3	18.58	.1818		
Fe_2O_3	4.38	.0274*		
CaO	1.32	.0235		
MgO	1.18	.0293		
H_2O	16.64	.8824*	.8750	5.3
	99.67			

* Fe_2O_3 4.38 corresponds to 5.12% limonite.
5.12% limonite requires 0.74% minus correction on H_2O.

This analysis is not reducible to simple molecular ratios. The iron is possibly present as limonite and if so taken the ratio be-

WOLCHONSKOITE FROM OKHANSK, SIBERIA

	1	Ratios	2	Ratios
SiO_2	37.01	.6138	36.84	.6109
Al_2O_3	6.47	.0633	3.50	.0342
Cr_2O_3	17.93	.1183	18.85	.1244
Fe_2O_3	10.43	.0653	17.85	.1118
Mn_2O_3	1.66			
MgO	1.91	.0474		
H_2O	21.84	1.2121	22.46	1.2465
PbO	1.01			
K_2O	trace		CaO 1.39	.0248
			100.89	

tween SiO_2 and R_2O_3 is 1:3; however, this is purely an arbitrary assumption. No suggestions can be made concerning the manner in which calcium and magnesium are combined. If the molecular ratio for H_2O is corrected for the theoretical quantity of water which must combine with iron to form limonite, a ratio of 5.3 for H_2O remains. We propose for the material the name rilandite. Wolchonskoite is chemically more nearly related to this material than any other compound described in the literature. The following analyses are taken from Dana.[9]

Since this is the only occurrence of this compound so far known, all that can be done at this time is to state the analysis and the ratios obtained. No definite formula is proposed.

It can readily be seen that there is a great difference between rilandite and wolchonskoite. In the National Museum's collections are specimens of wolchonskoite, from Okhansk, Siberia, which have a pronounced olive green color, and occur as a green clay-like mass in a brown sandstone.

A sample of analyzed rilandite from Routt County was given to Dr. E. Posnjak for x-ray study. He reports that the material, at least a large portion of it, is not amorphous. The diffraction lines are broad and the primary particles may be very small. Some of the lines correspond closely with the beidellite type of clay, although there are several strong lines that are different.

[9] Dana, J. D.; Dana, E. S., *A System of Mineralogy*, 6th ed. p. 696, 1892.

FOUR CRYSTALLINE HYDRATES OF SODIUM METASILICATE

CHESTER L. BAKER, H. TEYNHAM WOODWARD
AND ADOLF PABST

A number of compounds of the general formula $Na_2SiO_3 \cdot nH_2O$ are reported in the literature. P. Groth[1] gives crystallographic measurements for $Na_2SiO_3 \cdot 9H_2O$, described by Fritzsche;[2] $Na_2SiO_3 \cdot 8H_2O$, described by von Ammon;[3] and $Na_2SiO_3 \cdot 5H_2O$, described by Peterson.[4] Erdenbrecher[5] reports the following: $Na_2SiO_3 \cdot 9H_2O$, rhombic, melting point 47° C.; $Na_2SiO_3 \cdot 6H_2O$, monoclinic, melting point 62.5° C.; and $Na_2SiO_3 \cdot 4H_2O$, hexagonal, melting point 85° C. Harman,[6] from a study of the system Na_2O–SiO_2–H_2O at 25° C., claims to have identified by Schreinemakes residue method the following compounds: $Na_2SiO_3 \cdot 9H_2O$, $Na_2SiO_3 \cdot 6H_2O$, $Na_2SiO_3 \cdot 2\text{–}1/2H_2O$, and Na_2SiO_3. The work of other investigators who have found some evidence of hydrates up to 14 is summarized by James G. Vail.[7]

In the present work crystals have been prepared of sufficient size and perfection to enable positive identification of the nine, eight, six and five hydrates of sodium metasilicate. Melting points, densities, photomicrographs, optical properties and crystallographic measurements for these four crystals have been obtained.

PREPARATION OF CRYSTALS

In the preliminary work a series of solutions were prepared covering a wide range of Na_2O, SiO_2, H_2O compositions. These were protected from the air and allowed to stand at room temperature on a table protected from vibration. After a period of time crystals would form, usually as masses of very minute individuals. These were drained as dry as possible and centrifuged in a high speed laboratory machine. In every case the crystals were analyzed for chemical composition and examined microscopically as a means of identification. Out of a total of 271 trials extending over a period of three and one-half years, only four hydrates of sodium metasilicate were found.

A crystal of the chemical composition $Na_3HSiO_4 \cdot 5H_2O$ was identified and may be the compound variously reported as the two and one-half, three and four hydrates of sodium metasilicate.

Much difficulty was experienced in obtaining crystals of sufficient size and perfection for physical measurement. It was found necessary to use supersaturated solutions to obtain any appreciable rate of growth. Upon the slightest provocation there would separate a heavy mass of small feathery crystals, quite useless for accurate measurement. This necessitated many repeated trials and the development of a special technique before sufficiently good crystals could be obtained.

The method finally adopted was to obtain the mother liquor from which a heavy mass of crystals of the desired hydrate had separated. The mother liquor was heated and a portion of the crystals redissolved. The solution thus prepared was then divided among a number of beakers and placed inside of a large desiccator to cool. The solutions were protected from vibration by supporting the porcelain desiccator plate on three soft artgum rubber erasers. The desiccator in turn was supported on a three inch layer of absorbent cotton. The table carrying the desiccator was supported under each leg by a pyramid of four tennis balls. Other methods of protection from vibration were used but this method seemed to be the most satisfactory. When the solutions had cooled to near room temperature, a small carefully washed crystal of the desired hydrate was carefully introduced into each beaker. If the attempt proved successful, this seed would grow into a well developed crystal of from two to twenty millimeters greatest dimension. This growth required from one to twenty weeks depending upon conditions. Often, however, a mass of small crystals would separate so that the trial would have to be repeated. In most cases from twelve to eighteen months were required to secure desirable specimens.

TABLE I

SOLID PHASE	COMPOSITION OF SOLUTION	
	Wt. % of Na_2O	Wt. % SiO_2
$Na_2SiO_3 \cdot 9H_2O$	12.85	1.24
$Na_2SiO_3 \cdot 8H_2O$	13.02	3.64
$Na_2SiO_3 \cdot 6H_2O$	25.60	2.91
$Na_2SiO_3 \cdot 5H_2O$	26.60	1.68

The composition of typical solutions from which suitable crystals of each of the hydrates were grown is shown in Table I.

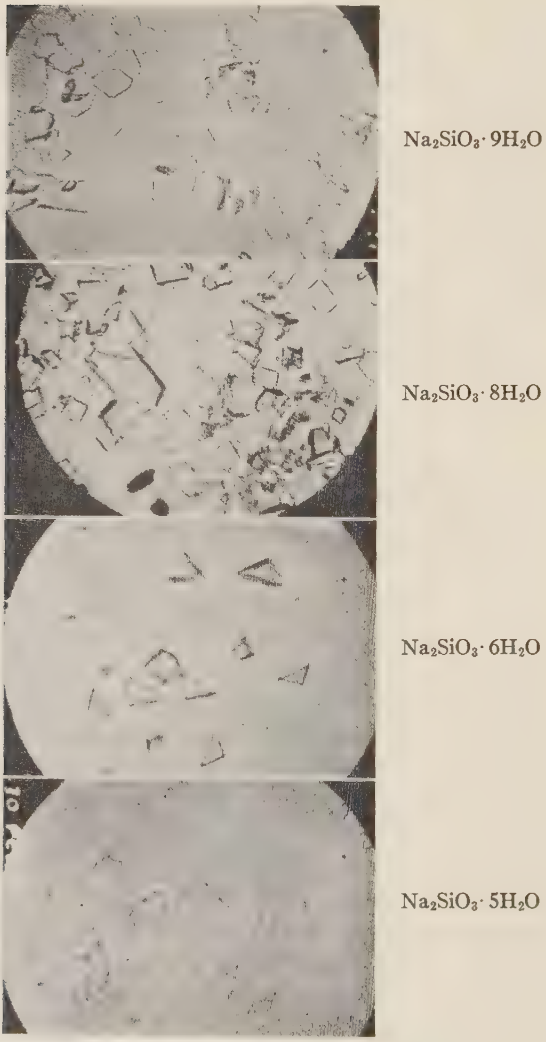

FIG. 1. Photomicrographs of the Four Crystalline Hydrates of Sodium Metasilicate.

PHOTOMICROGRAPHS

Rapid cooling of a supersaturated solution accompanied by agitation yields a suspension of minute crystals. Photomicrographs showing the different hydrates are shown in Fig. 1.

CHEMICAL COMPOSITION

All of these compounds are very alkaline. The *pH* of their solutions lie between those for Na_2CO_3 and NaOH when taken at equal normality. The crystals approach NaOH in hydroscopicity and like NaOH very quickly become carbonated when exposed to the air. These facts made it necessary to protect the crystals from the air as completely as possible and made the goniometric work to be described later very difficult.

TABLE II

		$Na_2SiO_3 \cdot 9H_2O$	$Na_2SiO_3 \cdot 8H_2O$	$Na_2SiO_3 \cdot 6H_2O$	$Na_2SiO_3 \cdot 5H_2O$
SiO_2	Calculated	21.14	22.56	26.09	28.31
	Found	21.08	22.56	26.07	28.27
Na_2O	Calculated	21.82	23.29	26.94	29.23
	Found	21.82	23.27	26.92	29.19
H_2O	Calculated	57.04	54.15	46.97	42.46
	Found	57.10	54.17	47.01	42.54

All crystals obtained showed a tendency to carry inclusions. Most of these could be removed by holding the crystals for several days in a thermostat at a temperature just below the melting point and recentrifuging. Chemical analyses on good specimens prepared in this manner are given in Table II.

DETERMINATION OF DENSITY

The crystals used in this work were freed from inclusions as described above. The densities were determined in a pyknometer using kerosene as the immersion liquid. In the case of the octahydrate the density was also determined by suspending a large crystal (40–50 grams) by a platinum wire and weighing in air and in kerosene. Because of possible microscopic inclusions the results were judged to be accurate to only the third decimal place and were not corrected to density in vacuum. Table III gives the average for at least three closely agreeing determinations.

DETERMINATION OF MELTING POINTS

The melting points were determined by rotating the crystals in a thermostat and raising the temperature about .05° per day. Whenever any moisture appeared due to melted-out inclusions, it was removed by centrifuging and the purified crystals replaced. The results obtained are judged to be accurate to ±0.05°C. They are given in Table III. The values obtained for the nine and six hydrates are somewhat higher than those given by Erdenbrecher, but since he used the warming curve method, his values would not be expected to be accurate to more than ±0.5°C. Considering this fact there is good agreement.

TABLE III

Compound	Density at 20° C.	Melting points found ° C.	Erdenbrecher melting points °C.
$Na_2SiO_3 \cdot 9H_2O$	1.646	47.85	47.0
$Na_2SiO_3 \cdot 8H_2O$	1.672	48.35	
$Na_2SiO_3 \cdot 6H_2O$	1.807	62.85	62.5
$Na_2SiO_3 \cdot 5H_2O$	1.749	72.20	

OPTICAL PROPERTIES

The optical properties of the several hydrates have recently been determined by H. E. Merwin and reported by A. N. Winchell.[8] The data obtained on our materials are in substantial agreement with those reported by them.

The densities and indices of refraction do not show a regular increase with decreasing water content as would be expected. However, the changes are in the same sense for both properties and this affords a rough check on the observations, as shown below:

CRYSTAL	DENSITY	MEAN INDEX OF REFRACTION, $N=\alpha+\frac{\beta+\gamma}{3}$ OBSERVED
$Na_2SiO_3 \cdot 9H_2O$	1.646	1.455
$Na_2SiO_3 \cdot 8H_2O$	1.672	1.462
$Na_2SiO_3 \cdot 6H_2O$	1.807	1.474
$Na_2SiO_3 \cdot 5H_2O$	1.749	1.456

CRYSTALLOGRAPHY

$Na_2SiO_3 \cdot 9H_2O$: Orthorhombic crystals of $Na_2SiO_3 \cdot 9H_2O$ have been described by Nordenskiöld.[2] On crystals obtained in the course of the present work the following forms, listed in order of importance, were found: *a*{100}, *b*{010}, *o*{111}, *x*{241}, *k*{021}, *y*{421} and *z*{310}. The last two had not been observed before. Most of the crystals have the habit shown in Fig. 2. Some are tabular to {100}. The following table gives the coordinate angles for all the forms as obtained by measurement on the two-circle goniometer.

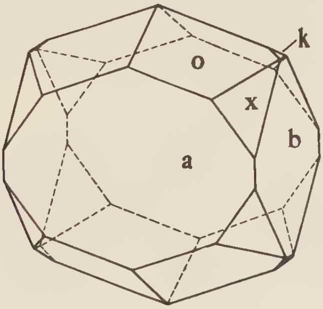

FIG. 2
$Na_2SiO_3 \cdot 9H_2O$
a {100}, *x* {241},
b {001}, *k* {021},
o {111},

FORM		MEASURED				CALCULATED			
		ϕ		ρ		ϕ		ρ	
b	{010}	0°	—	90°	—	—	—	—	—
a	{100}	89°	59′	90	—	90°	—	90°	—
o	{111}	55	20	31	3	—	—	—	—
x	{241}	35	53	59	15	35	52	59	23
k	{021}	—	3	34	22		0	34	24
y	{421}	71	17	64	14	70	56	64	30
z	{310}	77	27	90		77	1	90	—

From these measurements the axial ratio,

$$a:b:c = 0.6916:1:0.3424$$

is obtained. This is in fair agreement with the value 0.6888:1:0.3378 found by Nordenskiöld.

$Na_2SiO_3 \cdot 8H_2O$: Monoclinic crystals of $Na_2SiO_3 \cdot 8H_2O$ have

been described by von Ammon.[3] The crystals obtained in this work show a striking change in habit with change in the conditions of growth. From nearly congruent, slightly supersaturated, solution simple prismatic crystals with the forms $n\{120\}$, $r'\{\bar{1}01\}$ and $q\{011\}$, are grown. From solutions containing an excess of alkali, or from highly supersaturated solutions, flat plates parallel to $\{\bar{1}01\}$ with the forms $m\{110\}$, $q\{011\}$ and sometimes $n\{120\}$ and $f\{299\}$, as shown in Fig. 3 are produced. The form $\{299\}$ has not been reported, whereas numerous forms reported by von Ammon were not found on our crystals.

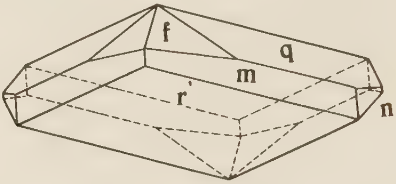

FIG. 3
$Na_2SiO_3 \cdot 8H_2O$ grown from a solution containing an excess of NaOH
$m\ \{110\}$, $r'\ \{\bar{1}01\}$, $f\ \{299\}$.
$n\ \{120\}$, $q\ \{011\}$,

The coordinate angles obtained by two-circle measurements are given below.

	Form	Measured				Calculated			
		ϕ		ρ		ϕ		ρ	
m	{110}	58°	52′	90°	—	—	—	—	—
n	{120}	39	38	90	—	39	37′	90°	—
r′	{$\bar{1}$01}	270	—	35	57′	270	—	—	—
q	{011}	32	52	40	20	32	40	—	—
f	{299}	45	23	45	15	45	16	45	27′

These measurements lead to the axial elements:

$$a:b:c = 0.6644:1:0.7148;\ \beta = 65°\ 23'$$

This result differs substantially from that obtained by von Ammon,[3] $a:b:c = 0.6352:1:0\cdot6721$, $\beta = 70°\ 12'$, but the description of the crystals and the similarity of certain interfacial angles leaves no doubt as to the identify of the materials.

$Na_2SiO_3 \cdot 6H_2O$: Crystals of $Na_2SiO_3 \cdot 6H_2O$ have not been measured previously. In the present work monoclinic crystals of the hexahydrate of two very different habits were obtained. Fig. 4 shows the habit of crystals grown at room temperature with the

forms: $a\{100\}$, $m\{110\}$, $s'\{\bar{1}\bar{1}1\}$, $u\{2\bar{1}\bar{1}\}$, $c\{001\}$, $r'\{\bar{1}01\}$ and $t\{20\bar{1}\}$. They clearly belong to the sphenoidal class, (C_2), of the monoclinic system.

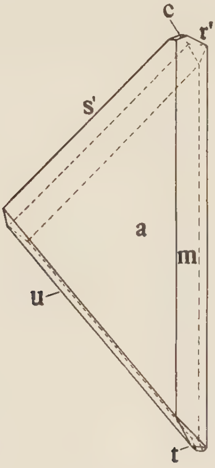

FIG. 4

$Na_2SiO_3 \cdot 6H_2O$ grown at room temperature

$a\ \{100\}$,	$t\ \{20\bar{1}\}$,
$m\ \{110\}$,	$s'\ \{\bar{1}\bar{1}1\}$,
$c\ \{001\}$,	$u\ \{2\bar{1}\bar{1}\}$.
$r'\ \{\bar{1}01\}$,	

Crystals grown at 50° C are short prismatic with the forms: $a\{100\}$, $m\{110\}$, $m'\{1\bar{1}0\}$, $c\{001\}$, $r'\{\bar{1}01\}$, $t\{20\bar{1}\}$ and $s'\{\bar{1}\bar{1}1\}$, the zone of the b-axis being most prominent.

The coordinate angles obtained by two-circle measurement are given herewith:

	FORM	MEASURED				CALCULATED			
		ϕ		ρ		ϕ		ρ	
a	$\{100\}$	90°	2′	90°	—	90°	—	90°	—
m	$\{110\}$	28	3	90	—	—	—	—	—
m'	$\{1\bar{1}0\}$	151	59	90	—	151	57′	—	—
c	$\{001\}$	89	59	12	16′	90	—	12	9′
r'	$\{\bar{1}01\}$	269	53	19	43	270	—	19	35
t	$\{\bar{2}01\}$	269	51	42	49	270	—	42	49
s'	$\{\bar{1}\bar{1}1\}$	198	21	48	29	—	—	—	—
u	$\{\bar{2}\bar{1}1\}$	220	51	54	52	220	50	54	47

The axial elements are:

$$a:b:c=1.9211:1:1.0727;\ \beta=77°\ 51'$$

$Na_2SiO_3 \cdot 5H_2O$: Although grown from very viscous solutions, many excellent crystals of $Na_2SiO_3 \cdot 5H_2O$ were obtained. They belong to the pinacoidal class, C_1, of the triclinic system. They do not in any way resemble the supposedly monoclinic crystals of this composition obtained by Petersen[4] and measured by Hessenberg. Since the older description did not include density or optical properties it would be hazardous to try to reconcile these differences.

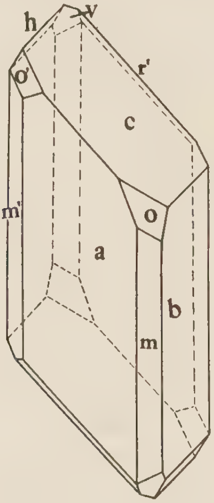

FIG. 5

$Na_2SiO_3 \cdot 5H_2O$ grown at 50° C.

$b\ \{010\}$, $c\ \{001\}$, $v\ \{\bar{1}\bar{2}1\}$,
$m\ \{110\}$, $o\ \{111\}$, $r'\ \{\bar{1}01\}$.
$a\ \{100\}$, $o'\ \{1\bar{1}1\}$,
$m'\ \{1\bar{1}0\}$, $h\ \{0\bar{2}1\}$,

The crystals, shown in Fig. 5, are very constant in habit. The principal forms are, $c\{001\}$, $b\{010\}$ and $a\{100\}$. The others, $m\{110\}$, $m'\{1\bar{1}0\}$, $o\{111\}$, $o'\{1\bar{1}1\}$, $h\{0\bar{2}1\}$, $v\{\bar{1}\bar{2}1\}$, and $r'\{\bar{1}01\}$, are minor forms which may be lacking.

The following table gives the measured and calculated coordinate angles of all forms observed on $Na_2SiO_3 \cdot 5H_2O$.

	FORM	MEASURED				CALCULATED			
		ϕ		ρ		ϕ		ρ	
b	$\{010\}$	0°	00′	90°	00′	0°	00′	90°	00′
m	$\{110\}$	59	12	90	00	60	00	90	00
a	$\{100\}$	108	59	90	00	108	49	90	00
m′	$\{1\bar{1}0\}$	142	13	90	00	141	42	90	00
c	$\{001\}$	10	23	38	24	10	28	38	25
o	$\{111\}$	43	00	64	40	43	12	64	44
o′	$\{1\bar{1}1\}$					121	05	59	26
h	$\{0\bar{2}1\}$	174	55	58	43	174	58	58	42
v	$\{\bar{1}\bar{2}1\}$	224	27	59	06	224	15	58	24
r′	$\{\bar{1}01\}$	316	35	59	38	316	31	59	22

The axial elements are:

$$a:b:c=0.7356:1:0.9005;\ \alpha=51°\ 52',\ \beta=81°\ 47',\ \gamma=70°\ 10'$$

It is interesting to note the regular decrease in symmetry with decrease in water content in this series of hydrates:

$Na_2SiO_3 \cdot 9H_2O$	rhombic bipyramidal
$Na_2SiO_3 \cdot 8H_2O$	monoclinic prismatic
$Na_2SiO_3 \cdot 6H_2O$	monoclinic sphenoidal
$Na_2SiO_3 \cdot 5H_2O$	triclinic pinacoidal

SUMMARY

Four definite hydrates of sodium metasilicate have been prepared and their physical and crystallographic properties determined.

A complete phase equilibrium study of the system Na_2O–SiO_2–H_2O is under way. The results of this work will be published at a later date.

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[4] Petersen, *Jour. für prakt. Chemie,* (2) **5**, 398, 1872.

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[6] Harman, *J. Phys. Chem.*, **31**, 511–518, 1927.

[7] Vail, Soluble Silicates in Industry, Chapter II.

[8] Winchell, A. N., The Microscopic Characters of Artificial Inorganic Solid Substances or Artificial Minerals. *New York*, **1931**, p. 284.

NOTES AND NEWS

OPTICALLY POSITIVE CORDIERITE FROM THE NORTHWEST TERRITORIES, CANADA

Ralph L. Rutherford, *University of Alberta.*

Several samples of rocks and minerals brought to Dr. J. A. Allan in 1929 from the district southeast of Great Slave lake contained some specimens that appeared to be cordierite from their general physical properties. The writer was asked to check this material by optical methods. In general, the optical properties agreed with those given for cordierite except that the sign was positive, whereas in most references it is reported as negative. Chemical tests were made for magnesium, silicon and aluminum and the proportions found present were satisfactory for cordierite. The specimens were set aside until such time as better sections could be prepared.

In the meantime an article by Cooke[1] appeared in which he discussed the mineralogical character of a spotted type of rock that he had previously named dalmatianite.[2] In the printed discussion of Cooke's article the question was raised as to the mineralogical composition of some of the spots. Cooke had determined the mineral to be feldspar. Walker[3] had also studied this spotted rock and concluded that cordierite was present in some of the spots. Merwin had determined the sign as negative for the material studied by Walker. Cooke states that if cordierite is sometimes optically positive, some of the minerals that he had determined as feldspar might be cordierite.

Since there appeared to be still some doubt as to the common occurrence of optically positive cordierite the writer had orientated sections prepared from the material sent in from the Northwest Territories. Further examination shows it to be definitely positive.

Optically positive cordierite has been reported from India[4] but apparently it has not been commonly observed.

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[1] Cooke, H. C., The Amulet Mine, Que.: *Trans. Can. Inst. Min. & Met.*, Vol. **xxxiii**, p. 398, 1930.

[2] Cooke, H. C., *Geol. Surv. Canada, Sum. Rept.* **1925**, Part C, p. 41.

[3] Walker, T. L., *Univ. of Toronto Studies, Geol. Series*, No. **29**, p. 9, 1930.

[4] Winchell A. N., Elements of Optical Mineralogy, II, p. 274, **1927.**

SIXTEENTH SESSION OF THE INTERNATIONAL GEOLOGICAL CONGRESS

The third circular for the sixteenth session of the International Geological Congress, which is to meet in Washington, U. S. A., from July 22 to 29, has been issued. It contains full information about meetings and about excursions, with costs. Before the Congress there are excursions to various parts of the eastern United States, lasting from 4 to 12 days, and a transcontinental excursion eastward from San Francisco for those coming to the Congress from the west. For those arriving at New York too late to take part in these longer excursions there will be a number of short trips to nearby areas of geologic interest.

Alternate days during the sessions of the Congress will be given to excursions to areas around Washington.

After the sessions there will be two longer transcontinental excursions, each lasting 31 days, and two shorter excursions, one for the study of the glacial geology of the Central States, the other for the study of the pre-Cambrian area, including the iron and copper deposits, of the Lake Superior region.

In order to make these excursions generally available, it has been possible, through the generous assistance of the Geological Society of America, to offer the longer excursions at a considerable reduction below actual cost.

For special discussion at the scientific sessions in Washington the following topics are announced:

Measurement of geologic time by any method.

Batholiths and related intrusives.

Zonal relations of metalliferous deposits.

Major divisions of the Paleozoic era.

Geomorphogenic processes in arid regions and their resulting forms and products.

Fossil man and contemporary faunas.

Orogenesis.

Geology of petroleum.

Copper resources of the world.

Membership in the Congress is open to any one interested.

For a copy of the third circular or other information address W. C. Mendenhall, General Secretary, U. S. Geological Survey, Washington, D. C.

The Oregon Agate and Mineral Society has been organized for the study of agates, semi-precious stones and minerals found in the state of Oregon. The following officers were elected at the first meeting: President, Dr. Henry C. Dake; Vice-President, Dr. E. W. Lazell; Secretary-Treasurer, Mabel V. Gordon (Mrs.). At the opening meeting, which was attended by about seventy-five members and visitors, Dr. E. W. Lazell addressed the society on "The Genesis of Quartz and Agates."

Dr. Charles W. Cook, a charter fellow of the Mineralogical Society of America, Professor of economic geology at the University of Michigan, died on Feb. 17, 1933, at Ann Arbor, Michigan, at the age of fifty years.

Dr. Louis Duparc, professor of mineralogy at the University of Genf and President of the Mineralogical and Petrographical Society of Switzerland, died on October 20, 1932, at the age of sixty-seven years.

Dr. Victor Goldschmidt of Heidelberg, Germany, celebrated his eightieth birthday on February 10.

Dr. Austin F. Rogers, professor of mineralogy at Stanford University, has been elected to membership in the Mineralogical Society of France.

Dr. Charles Palache and Dr. Friedrich Rinne have been elected honorary members of the German Mineralogical Society.

Mr. Lloyd W. Staples of the Michigan College of Mining and Technology has been appointed Teaching Fellow in Mineralogy at Stanford University for 1933–34.

Dr. E. S. Simpson, Government Mineralogist and Analyst of Western Australia, has been awarded the H. G. Smith Memorial Medal for 1932 by the Australian Chemical Institute in recognition of his original work in the field of mineral chemistry.

PROCEEDINGS OF SOCIETIES

NEW YORK MINERALOGICAL CLUB

Minutes of the November Meeting

A regular meeting of The New York Mineralogical Club was held at The American Museum of Natural History on the evening of November 16th, 1932, with an attendance of 35, due to the inclement weather. President Hawkins was in the chair.

Mr. J. W. Baker of Wrentham, Mass., Mr. Lucian M. Zell of New York City, and Mr. Raymond S. Howell of White Plains, N. Y., were elected to membership.

Mr. Morton reported on the Club's excursion to the Paterson Quarries on Election Day, November 8th: a splendid day, about sixty attended, and none were disappointed. At the West Paterson, N. J., quarry, sixteen minerals were found; at the Prospect Park quarry, nineteen minerals were found.

Dr. O. Ivan Lee volunteered to lead an excursion to the oldest copper mine in America—Schuyler copper mine near Arlington, N. J. His offer was accepted, for December 4th. Mr. Hoadley of the Excursion Committee having moved to Montreal, Quebec, Canada, Mr. H. R. Lee was appointed to fill his place by President Hawkins.

The question of age limits for membership was discussed and tabled.

The Secretary called attention to the original specimen of kunzite, used by Professor Charles Baskerville, who named this gem variety of spodumene after the founder of our Club.

The meeting was then turned over to the members for reporting on their "Summer Collecting Experiences." President Hawkins exhibited calcite from Penfield quarry, Rochester, N. Y., and from the vicinity of Roanoke, Va., washed gold from Rocky Mt., Va., wolframite and calcite in serpentine, glauberite and gypsum from West Paterson, N. J., millerite radiations, and an antimony lead compound called bindheimite. Mr. Morton described his visits to tourmaline localities in Maine. Mr. Radu exhibited tourmaline from Maine, also rose quartz, clear beryl, very black biotite, and blue apatite. Dr. O. Ivan Lee described the pegmatite dike at the Wyerman quarry near Newtown, Conn., where he collected black tourmaline, garnet, beryl, and rose quartz. Mr. Manchester reported molybdenite and albite from Bedford, N. Y., and aquamarine from Bayliss quarry. Miss Richardson and Mr. Ernest Weidhaas reported on their collections in Maine.

DANIEL T. O'CONNELL, *Secretary*

Minutes of the December Meeting

A regular meeting of the New York Mineralogical Club was held at The American Museum of Natural History on the evening of December 21st, 1932, with an attendance of 55. President Hawkins was in the chair.

Mr. John Rosch of White Plains, N. Y., Mr. Jack Downes of Jersey City, N. J., Mr. Oscar Thielman of Prospect Park, N. J., Mr. Frank B. Smithe of New York City, and Mr. Henry Ames Richards, Jr., of Stamford, Conn., were elected to membership.

A communication from the Philadelphia Mineralogical Club relative to their experiments with junior membership was read. The matter of junior members was tabled.

Mr. H. R. Lee of the Excursion Committee reported on the Schuyler Copper Mine excursion held on December 4th. About 50 members and friends of the Club guided by Dr. O. Ivan Lee entered the old mine. Mr. H. R. Lee furnished a summary of the copper and other minerals found, and also gave some interesting assays of copper ores of New Jersey.

President Hawkins referred to the finding of microscopic helical crystals of millerite (NiS) in the Mills Coal Vein, Wilkesbarre, Pa.

Motion pictures of the Paterson excursions of the Club on Election Days held in 1931 and 1932 were shown by the secretary.

The speaker of the evening was Dr. Benjamin L. Miller, Professor of Geology at Lehigh University, Bethlehem, Pa. His subject was "Minerals in the Vicinity of Bethlehem, Pa."

Professor Miller traced the geology of the region from the early pre-Cambrian gneisses through the various Paleozoic formations and then pointed out the varied mineral resources associated with these rocks. He exhibited a geologic map of the area taken from his bulletin on the district, published as a joint bulletin of the U. S. G. S. and the Pennsylvania Geological Survey.

President Hawkins extended the thanks of the Club for the excellent address.

Mr. James A. Taylor followed with a humorous and entertaining as well as instructive account of his auto excursion to California. He visited such famous localities as Placerville, Nevada City, Palo, Death Valley, Mesa Grande, etc., and exhibited a number of excellent specimens which he obtained.

DANIEL T. O'CONNELL, *Secretary*

Minutes of the January Meeting

A regular meeting of the New York Mineralogical Club was held at the American Museum of Natural History on the evening of January 18th, 1933, with an attendance of 75. President Hawkins presided.

The Membership Committee reported favorably on the following, who were then regularly elected active members of the Club:

Mr. Charles W. Ballard of New York City.
Miss Helen Lawlor of New York City.
Dr. Charles D. Pearce of Scarsdale, N. Y.
Mr. Leo Neal Yedlin of New York City.
Mr. Louis Perloff of New York City.
Mr. Paul H. Bilhuber of Douglaston, L. I.

On a motion by Mr. Stanton, the Treasurer, President Hawkins appointed Mr. Stanton, Mr. Ashby, and Mr. Manchester, to investigate an opportunity to acquire some very desirable specimens for the Club Collection.

The speaker of the evening was the noted authority on colloidal chemistry, Mr Jerome Alexander, M. Sc., who spoke on "Colloidal Aspects of Mineralogy." He proceeded in a delightfully entertaining and instructive manner to explain many mysteries as the manifestations of colloidal phenomena, including "Jack Frost" patterns on the window and the exotic coloring of minerals such as rose quartz. He considered colloids to be in large part composed of ultra-microscopically small particles and that all colloidal minerals will develop into crystalline substances after a lapse of time. Many minerals now crystalline may have passed through the colloidal state. President Hawkins thanked Mr. Alexander on behalf of the Club for his splendid talk.

There followed a discussion of the properties of bentonite and the phenomenon known as frazil ice, considered a colloidal form of ice. Mr. H. R. Lee vividly described his experiences with this form of ice, and ascribed anchor ice as due to the frazil coming in contact with rocks colder than the water.

DANIEL T. O'CONNELL, *Secretary*

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia,
February 2, 1933

President Trudell presided at a stated meeting of the society. Forty-four members and twenty-four visitors were present. Dr. Joseph L. Gillson was proposed for membership.

Dr. Alfred C. Hawkins of Rutgers College spoke on "New Jersey minerals." Reminiscences of experiences in the field were illustrated with lantern slides picturing many fine specimens from localities such as Mullica Hill, Bergen Hill, West Paterson, North Plainfield, Scotch Plains, Chimney Rock, the Arlington mine, and Moore Station. He exhibited a geode with barite and calcite crystals from New Brunswick; garnet and hexoctahedral magnetite from Franklin; and glauberite crystals from West Paterson—a recent and remarkable find. He ascribed the latter to a recent origin, stating that the mineral was not the glauberite which originally filled the well known cavities in the trap rock.

Minerals exhibited by members included prehnite and natrolite, recently obtained by Mr. Moyd at Goat Hill, N. J., and stilbite from Moore Station collected by Mr. Morgan. Dr. Newcomet exhibited an ultraviolet ray bulb for fluorescence work.

W. H. FLACK, *Secretary*

MINERALOGICAL SOCIETY OF GREAT BRITAIN AND IRELAND

MINERALOGICAL SOCIETY, January 26th, SIR JOHN S. FLETT, President, in the chair.

DR. L. J. SPENCER: *Meteoric irons and silica-glass from the meteorite craters of Henbury (Central Australia) and Wabar (Arabia).* The materials from these two recently discovered occurrences throw much light on the formation of meteorite craters. Such craters are not merely dents made on the earth's surface by the percussion of large meteorites; they are explosion craters due to the sudden vaporization of part of the material, both of the meteorite and of the earth, in the intense heat developed by the impact.

The meteoric iron from these two localities is of exactly the same type, namely a medium octahedrite containing 7.3% of nickel. At Wabar a 25 lb. mass and a few small fragments of iron were collected; but at Henbury thousands of masses of iron are scattered around the craters. In the smallest (10-yard) crater a group of four masses (440 lb.) was excavated at a depth of 7 feet. Many of the smaller pieces scattered around the craters are curiously twisted and bent, suggesting that they were torn in a plastic condition from the main masses by the force of the explosions. Further they show a partial obliteration of the lamellar structure with granulation of the kamacite, indicating that they reached a temperature of 850°C. The pieces of iron show different types of pitting resulting from subaerial and underground weathering, and they are all weathered remnants of larger masses, each consisting of a single crystal.

Silica-glass, which is of rare occurrence in nature, shows a remarkable development at Wabar. A snow-white, highly vesicular glass was formed by the fusion of the clean desert sand; and bombs of this material shot out from the craters were coated with a thin skin of black glass free from bubbles and containing iron and nickel in the same ratio as in the meteoric iron. This must have condensed on the surface from the vapours of silica, iron, and nickel, indicating temperatures up to 3,300°C. The silica-glass at Henbury is much less abundant, and being formed from a ferruginous sandstone it is less pure. These bombs of silica-glass present many points of resemblance to tektites.

Dr. A. Brammall and Mr. S. Bracewell: *Garnet in the Dartmoor granite: its petrogenetic significance.* Seventeen occurrences prove to be manganiferous almandines containing 3% to 22% of MnO. Two or more varieties may occur in a single hand-specimen of the granite. The more manganiferous varieties (7% MnO) are restricted to the tor-horizons; the less manganiferous varieties occur (a) below these horizons, (b) in shale-contaminated facies of the granite, and (c) in xenolithic hornfelsed shale. Basic igneous inclusions are barren of garnet, and grossularite, *not* almandine, occurs in contact-altered spilites. The mineral is attributed to contamination of the granite by country-rock—probably deep-seated shales. Ten Lake District occurrences show a similar variation (1.3%–7.3% MnO).

Mr. F. A. Bannister: *The identity of mottramite and psittacinite with cupriferous descloizite (cuprodescloizite).* (With chemical analyses by Mr. M. H. Hey). Oscillations, Laue and rotation photographs show that descloizite has an orthorhombic unit-cell with edges $a=6.05$, $b=9.39$, $c=7.56$Å, and space-group Q_h^{16}. The unit cell contains 4 $PbZn(VO_4)(OH)$. Powder photographs of descloizite, cuprodescloizite, mottramite, and psittacinite from the type localities are identical with each other. New chemical analyses and determinations of the water content at various temperatures together with the x-ray work show that all these minerals may be represented by the general formula $Pb(Cu, Zn)(VO_4)(OH)$. The water of constitution is not evolved until a dull red-heat. Thin incrustations of minute black crystals on sandstone from Harmer Hill, Clive near Shrewsbury, collected by Mr. Arthur Russell, are shown to be identical with mottramite from Mottram, St. Andrew's, Cheshire (H. E. Roscoe, 1876), i.e. cuprodescloizite carrying little or no zinc.

NEW MINERAL NAMES

Harbortite

Friedrich Brandt: Ein Neuer Typ von Eisen–Tonerdphosphat–Vorkommen (Maranhao, Nordbrasilien). (A new type of iron aluminum phosphat occurrence, Maranhao, Northern Brazil). *Chem. Erde,* 7, pp. 383–433, 1932.

NAME: In honor of Prof. E. Harbort.

CHEMICAL PROPERTIES: A hydrous phosphate of aluminum. $6\ Al_2O_3 \cdot 4\ P_2O_5 \cdot 17\ H_2O$. Analysis: SiO_2 2.8, TiO_2 1.0, Al_2O_3 33.4, CaO 1.2, Na_2O 3.7, P_2O_5 35.7, H_2O 18.0; sum 99.6 (Eleven other analyses given.)

PHYSICAL AND OPTICAL PROPERTIES: Color white, yellowish, brownish. G. = 2.781–2.798. Hd. = 5–5 1/2. The indices of refraction lie between 1.602 and 1.618. Birefringence weak. Parallel extinction and fibers show negative elongation. Debye-Scherrer's diagrams show the two forms to be identical but different from wavellite or krauerite (dufrenite).

OCCURRENCE: Found in a lateritic iron oxide cap as spherulites or pseudomorphous octahedrons, with dufrenite, amorphous aluminum phosphates and limonite. The deposit probably owes its origin to the action of phosphatic solutions from guano upon laterite.

W. F. FOSHAG

Kolbeckine

R. HERZENBERG: Kolbeckin Sn_2S_3, ein neues Zinnmineral (Kolbeckine Sn_2S_3, a new tin mineral). *Centr. Min., Abt. A.*, No. **11**, pp. 354–355, 1932.

CHEMICAL PROPERTIES: A sulfide of tin: Sn_2S_3, Analyses (after deducting impurities): S 6.11, 3.68, Sn 14.7, 9.00. In closed tube yields sulfur. Soluble in hydrochloric and sulfuric acids with evolution of hydrogen sulfide. Soluble in alkali hydroxides and alkali sulfides, from which HCl precipitates tin sulfide. Insoluble in ammonia.

PHYSICAL PROPERTIES: Color black, resembling fine grained pyrolusite.

OCCURRENCE: Found at the Maria-Teresa mine near Huari station between Oruro and Uyuni, as a filling in cavities and joints in a spongy cassiterite.

DISCUSSION: Ramdohr has examined a section of this ore but could detect no new mineral with certainty. He found, in the order of their abundance, quartz, pyrite, cassiterite, sphalerite, teallite (?), stannite, arsenopyrite and chalcopyrite.

W. F. F.

Enalite

KENJIRO KIMURA AND YASUO MIYAKE: On Enalite, a New Variety of Uranothorite, found in Naegi, Gifu Prefecture. *Jour. Chem. Soc.* Japan, **53,** 93–100, 1932 (In Japanese).

NAME: From the locality: Ena Prefecture, Gifu District.

CHEMICAL PROPERTIES: A hydrous silicate of thorium and uranium: $(Th, U)O_2 \cdot nSiO_2$. Analysis: CaO 0.73, PbO 0.95, Al_2O_3 3.01, Fe_2O_3 0.88, Ce_2O_3 11.59, Nd_2O_3 12.57, ThO_2 28.96, UO_2 10.63, SnO_2 4.81, TiO_2 1.37, SiO_2 5.82, P_2O_5 12. 52, ign. 5.59. Sum 99.43.

CRYSTALLOGRAPHICAL PROPERTIES: Tetragonal.

PHYSICAL AND OPTICAL PROPERTIES: Color orange yellow. G. = 4.873. $n = 1.68$. Birefringence weak.

OCCURRENCE: Found in sands associated with cassiterite and monazite at Kotzugusawa in Takayama, Fukuoka Village, Ena Prefecture, Gifu District, Japan.

W.F.F.

Stewartite

Alpheus F. Williams: The Genesis of the Diamond. vol. **2,** p. 471, 1932. London.

Name: From Mr. James Stewart, for many years manager of the De Beers concentrating plant.

A magnetic variety of bort. Polar.

W.F.F.

REDEFINITION OF SPECIES

Valleriite

P. Ramdohr and O. Ödman: Valleriit (="unbekanntes Nickelerz"=fragliches pleochroitisches Mineral), *Geol. Fören. Förhandl.*, **54,** 89–97, 1932. Also Schneiderhöln, H., and Ramdohr, P.: *Lehrbuch der Erzmikroskopie*, Vol. **II,** p. 127–130, 1931.

Chemical Properties: A sulfide of iron and copper—$Cu_2Fe_4S_7$. Analysis: Cu 14.37, Fe 24.03, S 24.96, Al_2O_3 6.54, MgO 19.25, insol. 2.81. Easily soluble in warm hydrochloric acid.

Crystallographical Properties: Probably hexagonal or pseudohexagonal, with the forms: (0001), (1010), and a steep pyramid.

Physical Properties: Color black. Soft, can be cut with the fingernail and marks paper like graphite. Luster is fairly high on surface but dull on cross fracture. Cleavage good.

Mineralographical Properties: Color white to cream yellow, almost like pentlandite. Reflection pleochroism strong, O=pale yellow toward rose, E=dull gray, somewhat bluish. Strongly anisotropic. Extinction parallel to the cleavage. Sometimes shows twinning lamellae. Etching: with nascent Cl positive. HCl (conc.), HNO_3 (conc.) and aqua regia, negative.

Occurrence: Found in bean-shaped grains up to the size of a hazel-nut and distinctly layered, concentric about a nucleus; or as a felted fine grained aggregate in carbonate rock at Kaveltorp, Sweden. Also intimately intergrown with chalcopyrite and pentlandite in the basic rocks of the Bushveld complex.

W. F. F.